Space Weather Technical Forecast

Issued on Thursday 23 January 2025 at 12:16 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance G2 in UTC weekend. R1 Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity was at Low levels, with GOES16 registering occasional C-class activity, peaking with a C9.1 observed at 23/0203UTC from AR3961 in the southwest quadrant.

There are currently eight sunspot regions on the Earth-facing disc. The largest region on the disc, AR3961 an Ehi/Beta-Gamma in the southwest appears to be in a mature phase, with slight reduction in penumbral area in its central and trailing portions. By contrast, two regions were seen to grow rapidly in the period: AR3972 in the southeast, which now manifests as a Dsi/Beta-Delta, with the delta spot lying to the northeast; and finally AR3965 also grew in the northwest, soon becoming a Dai/Beta. Other regions' changes were generally slower, although AR3969 in the east was perhaps the most notable of these, in seeing some minor intermediate spot development.

No new Earth-directed Coronal Mass Ejections (CMEs) were in evidence - a disappearing filament at 23/0500UTC on Learmonth H-alpha from near S25W025 was not obviously apparent on available coronagraph imagery - although a naarrow feature seen heading southwest will be assessed.

Prior to this reporting period, the M1.3 flare peaking at 22/1108UTC was associated with a filament eruption to the east of AR3961. This CME has been (re-)assessed as bearing a potential Earth-bound component, and may cross 1AU (mainly below the ecliptic) into the UTC evening of Saturday 25 January. This is expected to follow on the heels (passing 1AU within the same UTC day) of a still fainter glance from an earlier CME associated with the M3 flare on 21 January, from AR3967. Coronagraph activity in the past 24-hour period was otherwise identified as far-sided, with the arriving eastern limb perhaps harbouring significant regions, judging from recent CME evidence triangulated to 100-110E.

Solar Wind / Geomagnetic Activity: Earth appears to be transiting a sector of space affected by the waning influence from the fast wind from CH09/-. The solar wind speed, as measured by ACE and DSCOVR at L1 was Slightly Elevated and ranged between 475 and 450km/s with a slight downward trajectory. The solar wind density was complicated according to which observing satellite was employed, but was generally within background at single figures ppcc. The IMF was small-scale but erratic near a peak fo 5nT, with a north-south component varying between +/-4nT. The phi angle remained negative (towards the Sun).

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The net result of the above solar wind measures was Quiet to Unsettled geomagnetic activity, with a provisional peak Kp of '3+' in the 00-03UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 showed a slight upward response in the 10MeV channel from 22/1800UTC, albeit peaking below 1pfu. The cause is not clear, but may be related to an indirect particle route from the M1.3 filament seen 22/1108UTC, or else a far-sided event.

High energy electron flux (greater than 2MeV) at GOES16 was mainly Moderate but with a diurnal High peak of 1500pfu seen at 22/1705UTC. The associated 24-hour fluence persisted below the Active threshold, reaching 4.9e7 integrated pfu at 23/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is forecast, with isolated M-class flares Likely and with a Slight Chance of isolated X-class flares.

Solar Wind / Geomagnetic Activity: The only coronal hole to feature in the period is the current tail end of CH09/-. This should now play no part in forecast geomagnetic activity.

By contrast, up to two CMEs now feature in the forecast - firstly that from an M3 from AR3967 on 21 January, and secondly a filament- and M1.3-related event near AR3961 from 22/1108UTC. There is a Chance of G2 Moderate geomagnetic storm intervals on Saturday 25 January, with this risk reducing later in the UTC weekend.

Energetic Particles / Solar Radiation: There remains a Slight Chance of enhancements exceeding the S1 Minor Radiation Storm threshold should any notable flares occur.

GOES16 high energy electron flux is forecast to decline from current levels, hastening at GEO should any CME effects materialise and remaining below 24-hour Active fluence throughout.

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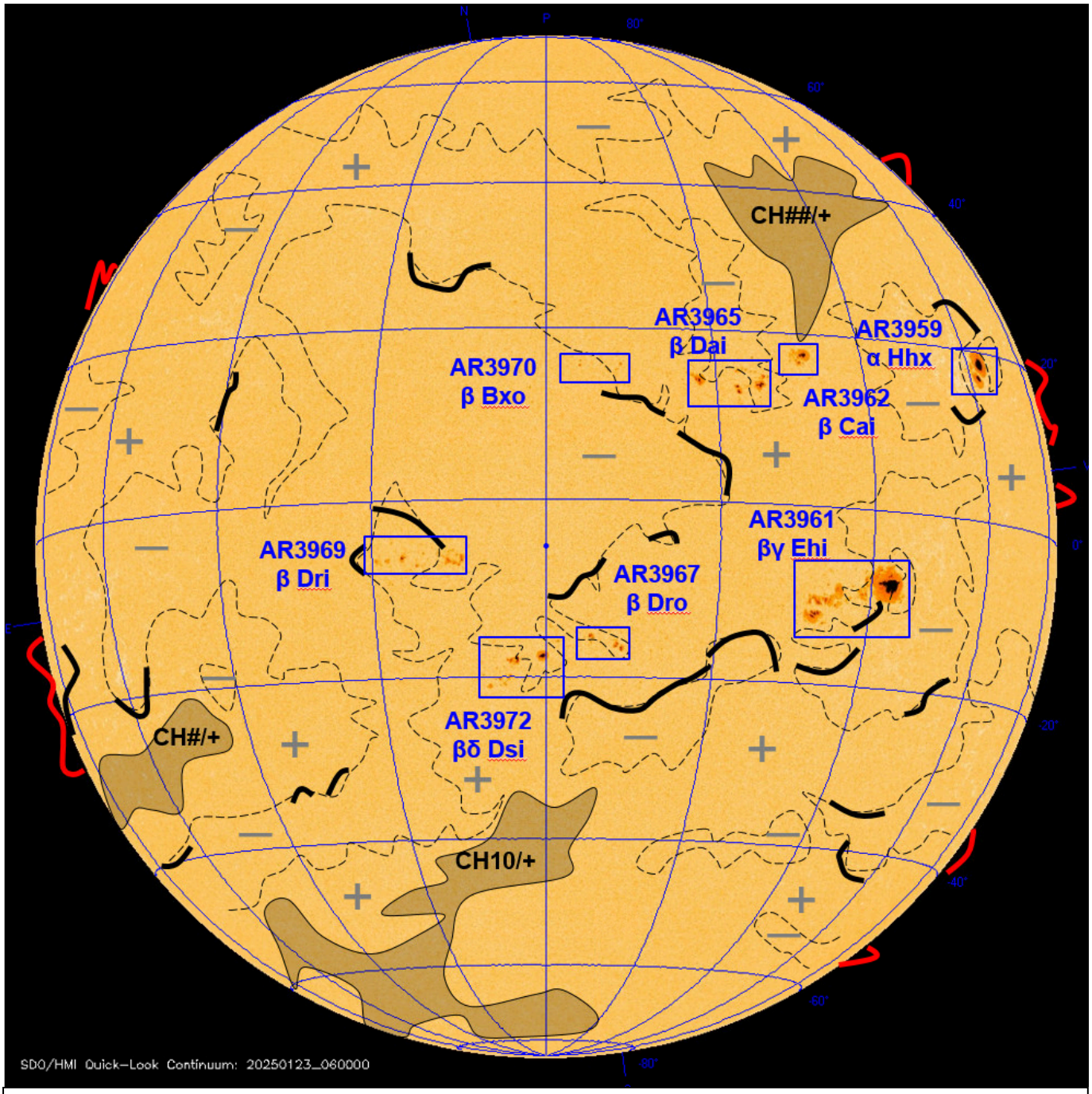
Figure 1: MOSWOC solar synoptic map, valid 23/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

The only coronal hole to feature in the period is the current tail end of CH09/-, with speeds still Slightly Elevated but much-reduced from their 21 January peak in the upper 600s of km/s. This should now play no part in increased geomagnetic activity given the small (5nT) IMF and reducing wind speed.

By contrast, up to two CMEs now feature in the forecast - firstly that from an M3 from AR3967 on 21 January, and secondly a filament- and M1.3-related event near AR3961 from 22/1108UTC.

Of the CMEs, the first event is of lesser concern, being modelled in MOSWOC Enlil as a slight glancing blow early in the UTC day of Saturday 25 January. On its own, this might perhaps present a Slight Chance of G1, however it may be rendered more significant for any priming of the Earth's magnetosphere in advance of the later, less-glancing and larger event from the M1.3. This has been re-analysed as presenting a Chance of Moderate G2 into the UTC evening of Saturday 25 January, with a full halo shock but with the dark helicoidal filament emission (in AIA304) perhaps appearing confined to the southern solar hemisphere (i.e. mainly below the Sun-Earth line). Imagery for the event is reasonable, and speeds obtained from fitting closely match the Type II radio emission estimation of 561km/s (550-600km/s from CME fits). MOSWOC Enlil is currently slightly over-estimating the speeds from the declining phase of CH09/-, which may slightly late-shift the inbound CMEs which otherwise cross 1AU around 25/0600UTC and then 25/1800UTC. The deterministic runs keep these as separate events, however there is a small chance that they coincide (as shown in the MOSWOC Enlil ensemble), which is the reason for the non-zero but not favoured risk of Strong G3. These probabilities then fade through the second half of the weekend (UTC) to leave a Quiet start to the forthcoming new working week.

All considered, an initially Quiet end to the UTC working week may give way to a Chance of a Moderate G2 geomagnetic storm, waning over the remainder of the UTC weekend. There is a not-insignificant alternative possibility that Quiet conditions remain in place throughout the four days - should both CMEs miss.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	40	30
Strong	G3	No	1	1	15	10
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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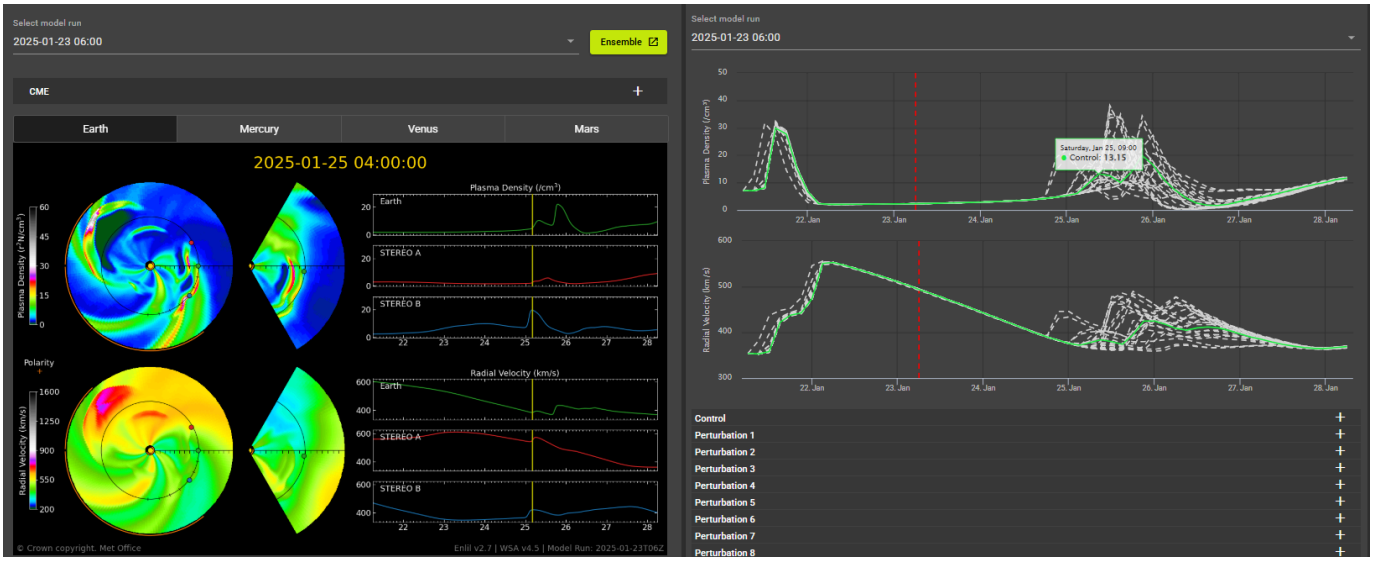
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
21/1027	Partial	AR3967	SE	537	25/0600	Small chance of glance and G1, perhaps primes magnetosphere to increase impacts from later CME.
22/1727	Full	AR3961	S Centre	591	25/1800	Greater chance of glance relative to above, G2 most likely.

Figure 2: MOSWOC Enlil run and ensemble from 23/0600UTC, paused at the 1AU crossing time of the 21 January M3 CME, with the later M1.3 CME seen to be inbound at roughly 0.75AU at the same time. The ensemble suggests mainly resolved peaks, however some solutions are overlaid, which is the rationale for the small chance of G3 in a more likely forecast of G2. Enlil itself is perhaps a little fast in its modelling of the exit from CH09/-, perhaps giving delayed effects into the second half of the UTC weekend.



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Radio Blackouts - X-Ray Flares

The current Earth-facing disc is showing a westward bias in active region populations, with the far side conversely showing an eastward shift, i.e. diametrically opposite. This means that trends in the coming four-day forecast period will rely on arrivals trading off against any departures.

Despite the westward-shift, on the front side only AR3959 departing the disc into the UTC weekend, with the most active region (AR3961) remaining present for all days of the period. There are reasons to suggest that the arriving eastern horizon may yet reveal large active regions, with up to two large CMEs seen emanating from 100-110E in the past 24 hours.

All considered, the daily Likely M-class flare risk is maintained throughout the period, with any reduction in the global risk from AR3961's slowing output perhaps being helped back upwards by any new east limb arrivals into the UTC weekend. The risk of X-class flares has been revised downwards slightly to fit the current state of the Earth-facing disc.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	70	70	70	70
Very Active	R3-R5 (X Class)	No	10	10	10	10

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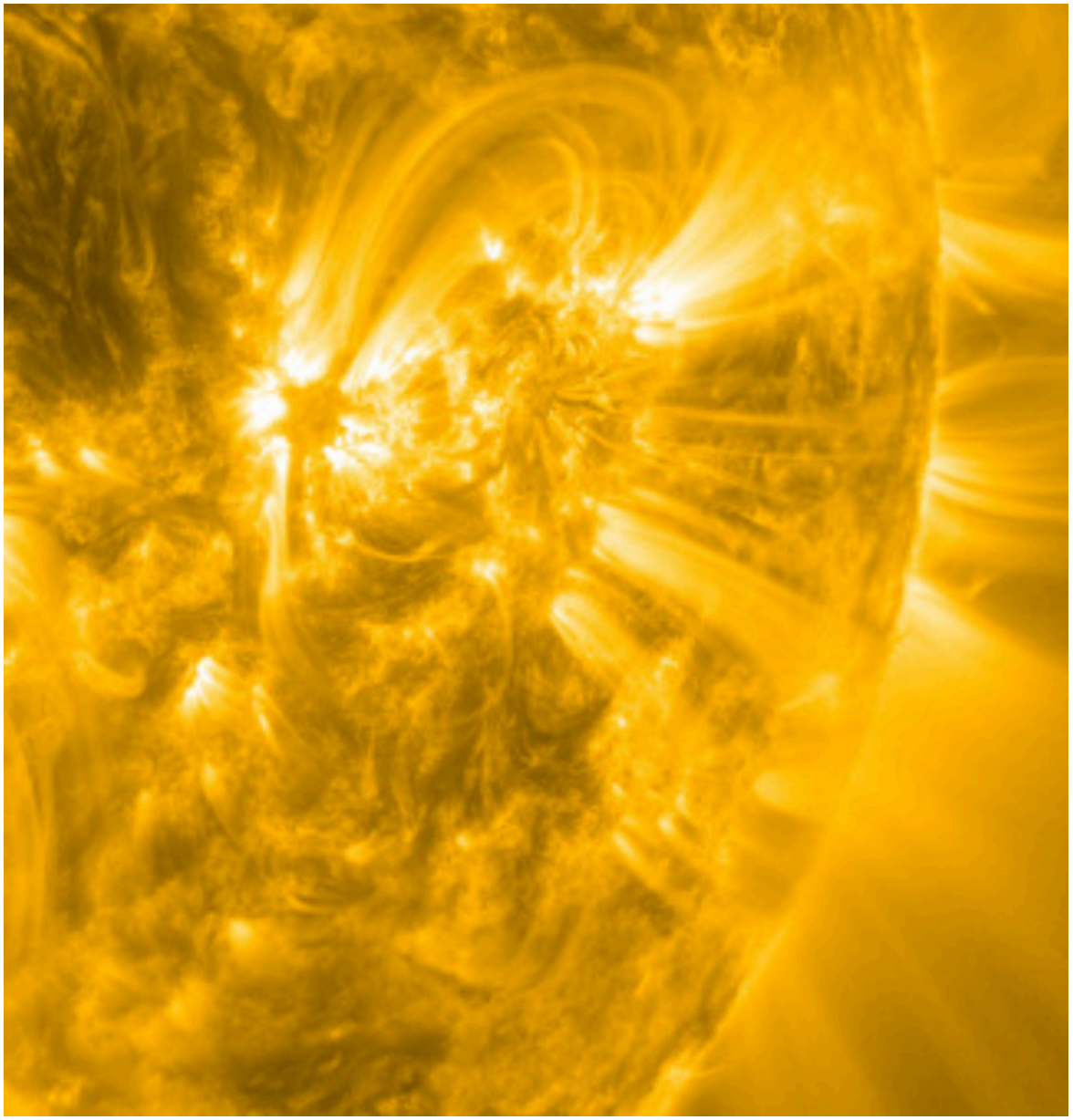
Figure 3: 23/1130UTC view of AR3961 in AIA171, showing a proxy for the emanating field, which currently appears to be a relatively straightforward dipole.



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Solar Radiation Storms (High Energy Protons)

High energy proton flux at GOES18 showed a slight upward response in the 10MeV channel from 22/1800UTC, albeit peaking below 1pfu. Higher energies remained unmoved.

The cause of this enhancement is not immediately clear, but may be related to either far-sided activity, or else an indirect particle route from the M1.3 filament seen 22/1108UTC (i.e. a 'highly-curved' trajectory passing 'around' the Sun given the slow and damped response). This lends credence to the idea that AR3961 may be capable of further such events, which may make it one to watch as it crosses into a more directly-connecting environment in the period. Current high energy proton counts add little to the daily probability of exceedence given their modest magnitude, however a slight day-on-day increase in a Slight Chance of S1 is suggested, given the westward advance of a westward-biased disc (in terms of sunspot population).

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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Figure 4: Past 72 hours in GOES16 X-ray flux, and potentially linked GOES18 proton flux, showing an eventual enhancement from 22/1800UTC. The cause is uncertain, but is either far-sided or perhaps a very indirect result of earlier M- or high C-class activity from centre-disc.

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 has shown a recent diurnal peak of High flux and 1500pfu. This has arisen from the declining phase of connection to CH09/-, with this driving feature now lying on the western limb.

No further coronal holes are due in the period, however there is the complicating influence of up to two inbound CME glances within the UTC day of Saturday 25 January. MOSWOC REFM's initial trajectory is accepted in showing a retreat from current levels to end the UTC working week, however its forecast is not considered useful from the UTC weekend given transient effects. All considered, the diurnal oscillation should be near equilibrium at present and a slight waning at GEO should accelerate in earnest once any CMEs arrive on day three, Saturday 25 January.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	20	20	20	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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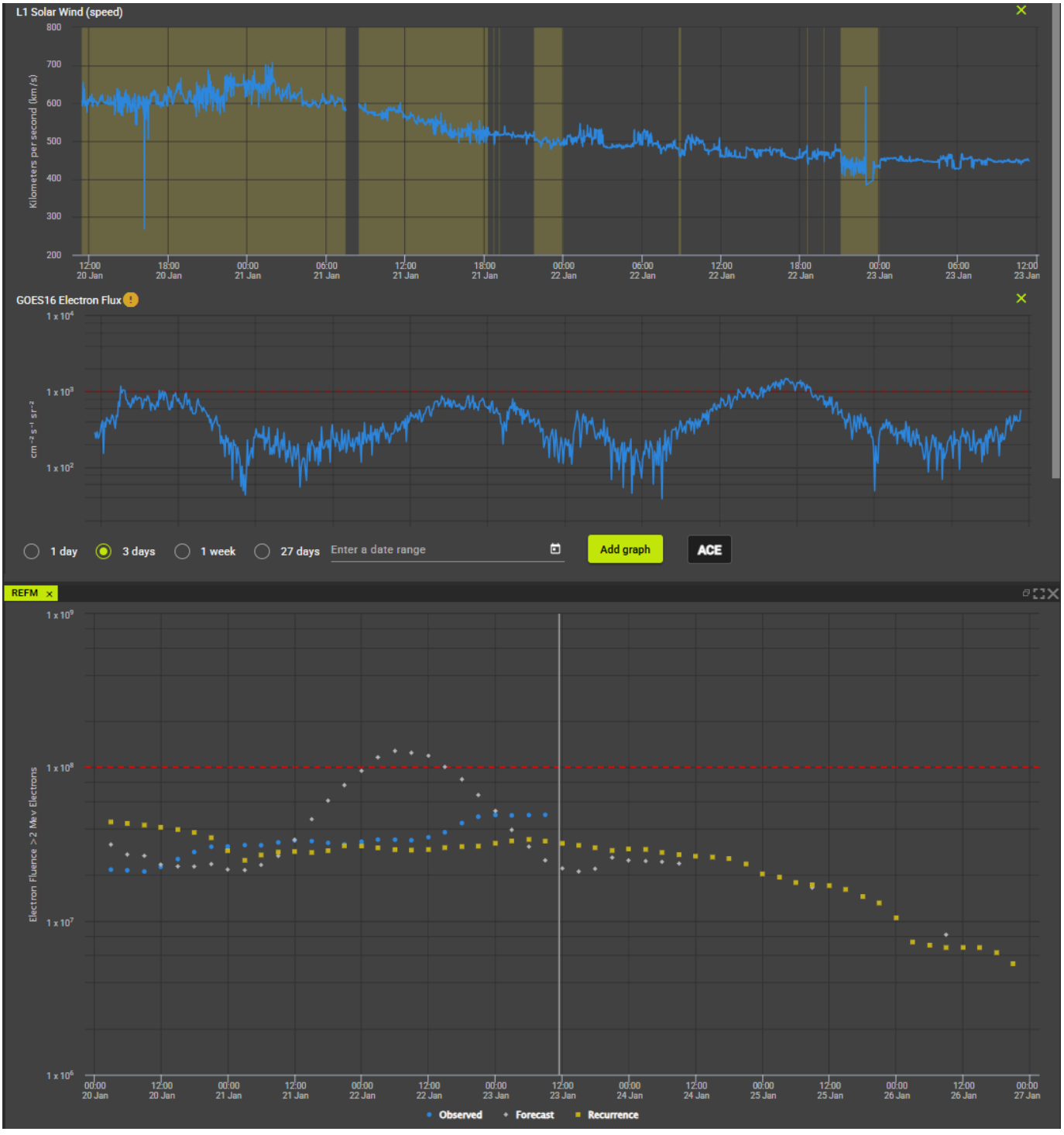
Figure 5: Past 72 hours in L1 solar wind speed showing exit from CH09/- starting 21 January. Resultant GOES16 high energy electron flux can be seen to be stablising, as can 24-hour fluence trend (bottom plot, blue dots). MOSWOC REFM's forecast can be seen below, and although the initial trend downwards is accepted, confidence falls away with the arrival of any CME(s) on 25 January.



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